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Moon et al.

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(54) **METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE**

(56) **References Cited**

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(57) **ABSTRACT**

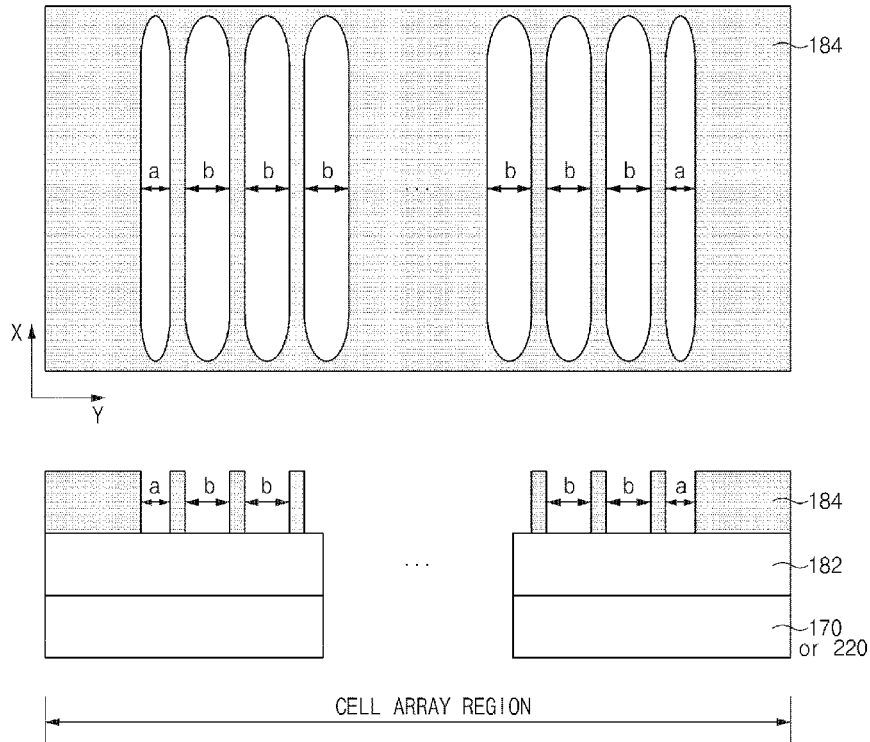
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Nov. 1, 2018 (KR) 10-2018-0132751

A method for forming a semiconductor device is disclosed. The method for forming the semiconductor device includes forming a first sacrificial film over a target layer to be etched, forming a first partition mask over the first sacrificial film, forming a first sacrificial film pattern by etching the first sacrificial film using the first partition mask, forming a first spacer at a sidewall of the first sacrificial film pattern, and forming a first spacer pattern by removing the first sacrificial film pattern. The first partition mask includes a plurality of first line-shaped space patterns extending in a first direction. A width of at least one space pattern located at both edges from among the plurality of first space patterns is smaller than a width of each of other space patterns.

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H01L 45/00 (2006.01)
(52) **U.S. Cl.**
CPC **H01L 45/1666** (2013.01); **H01L 45/06** (2013.01); **H01L 45/12** (2013.01); **H01L 45/144** (2013.01); **H01L 45/145** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

12 Claims, 15 Drawing Sheets



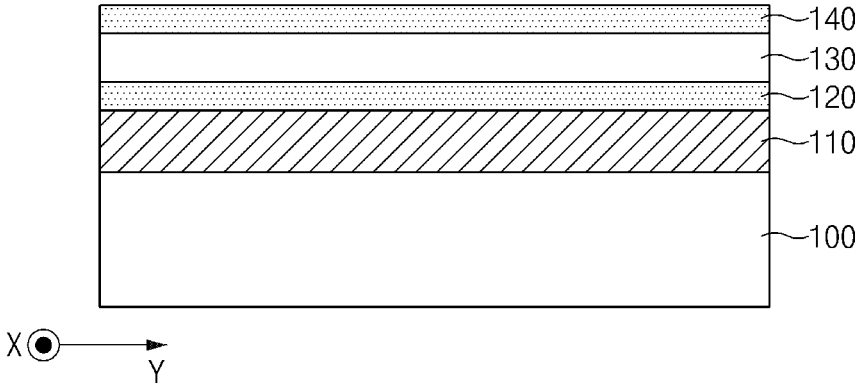


FIG. 1A

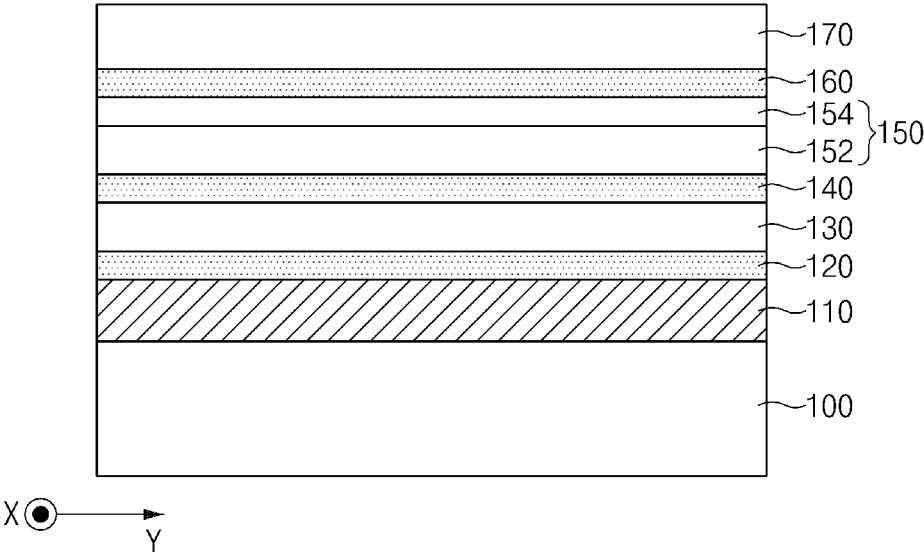


FIG. 1B

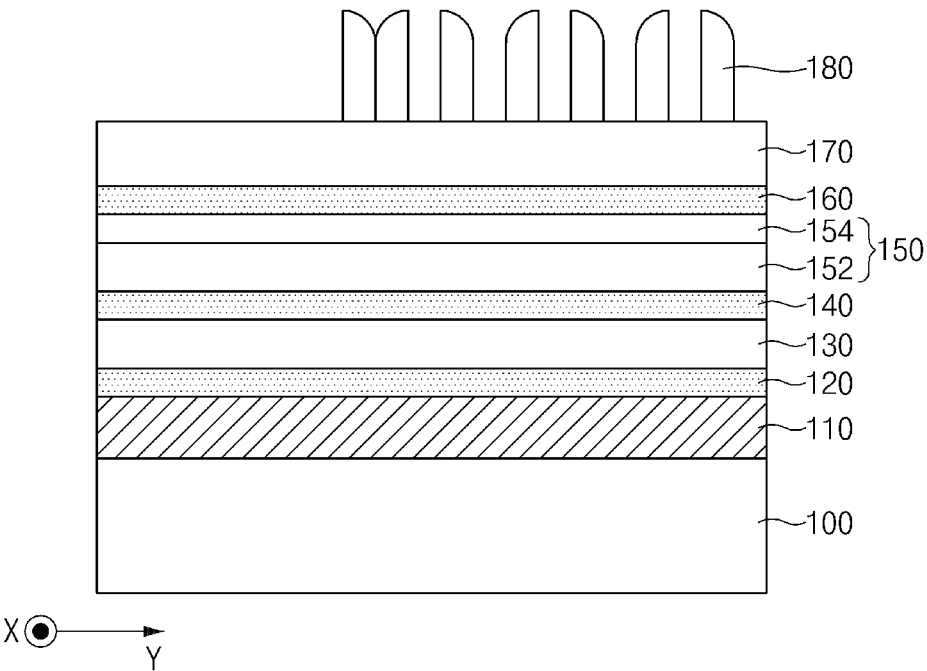


FIG. 1C

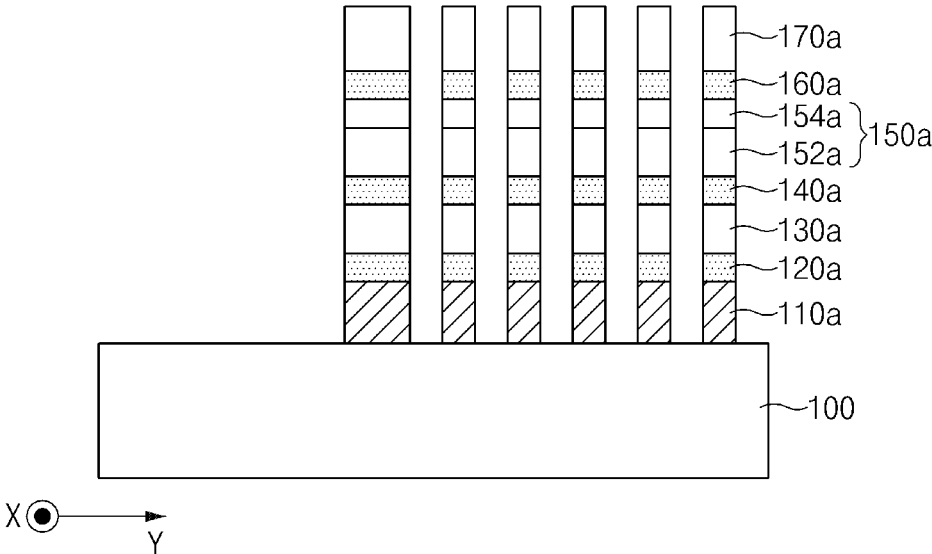


FIG. 1D

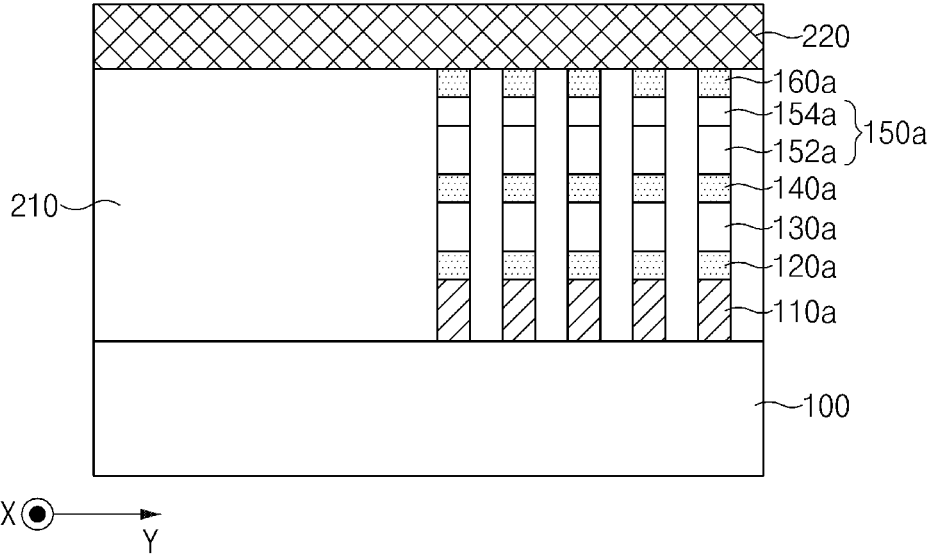


FIG. 1E

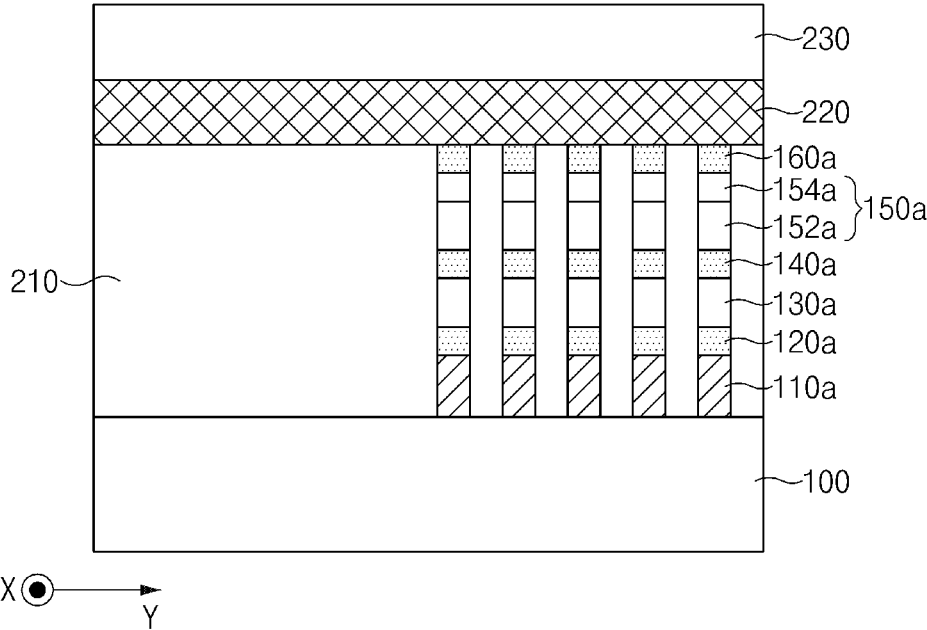


FIG. 1F

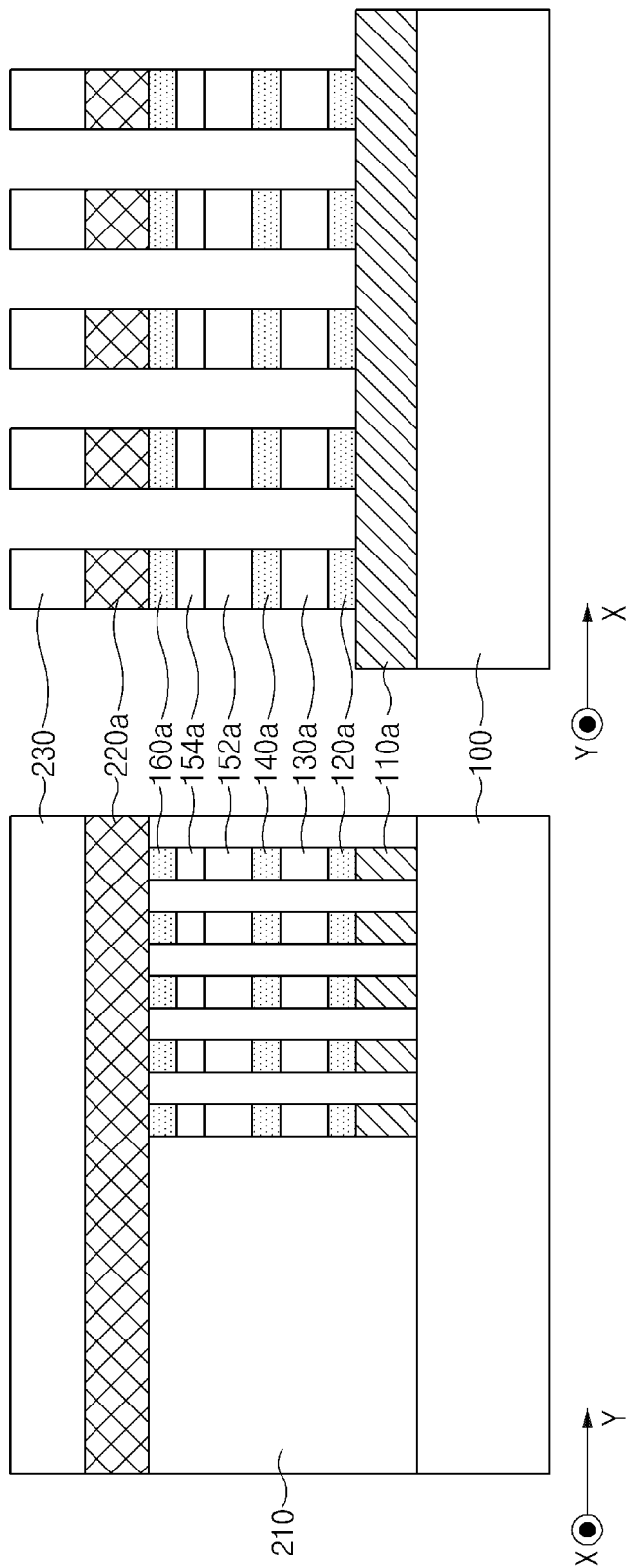


FIG. 1G

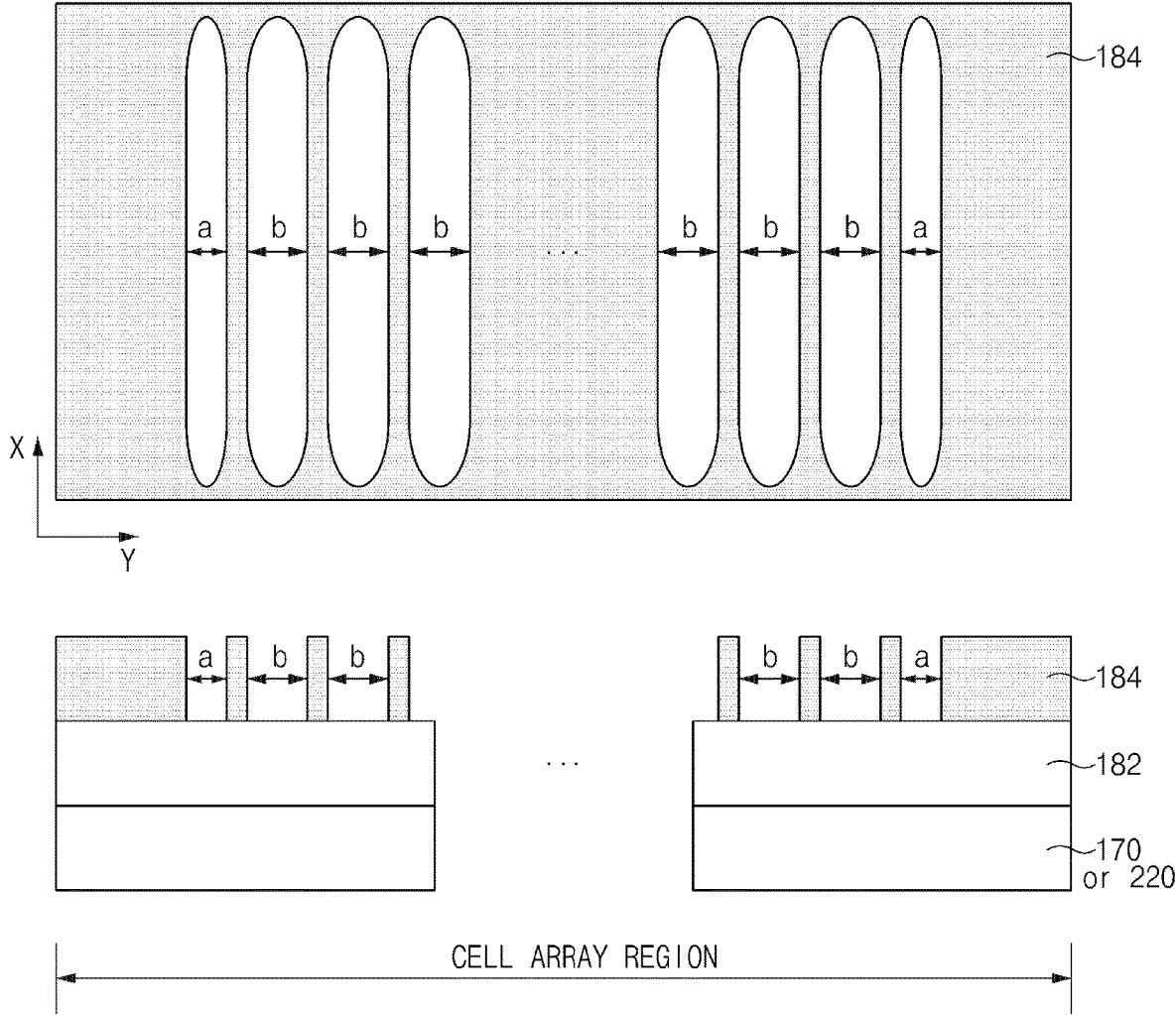


FIG. 2A

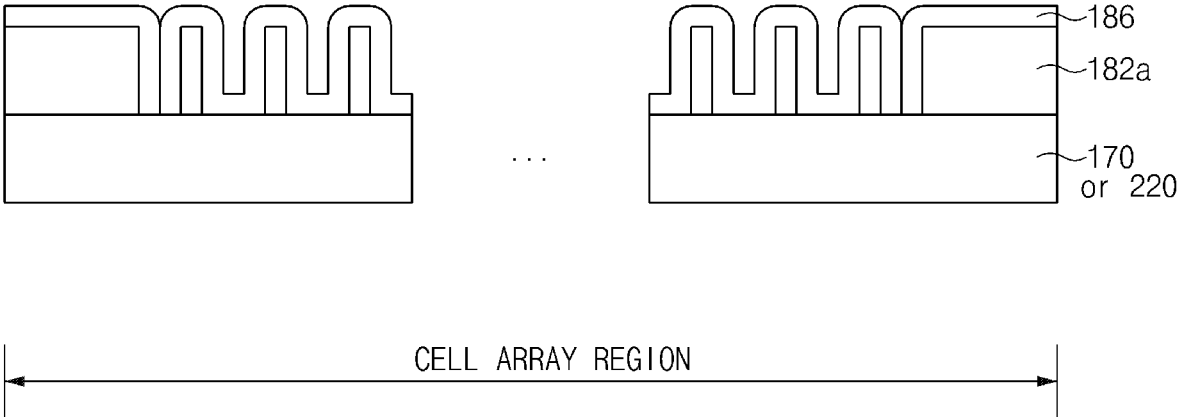


FIG. 2B

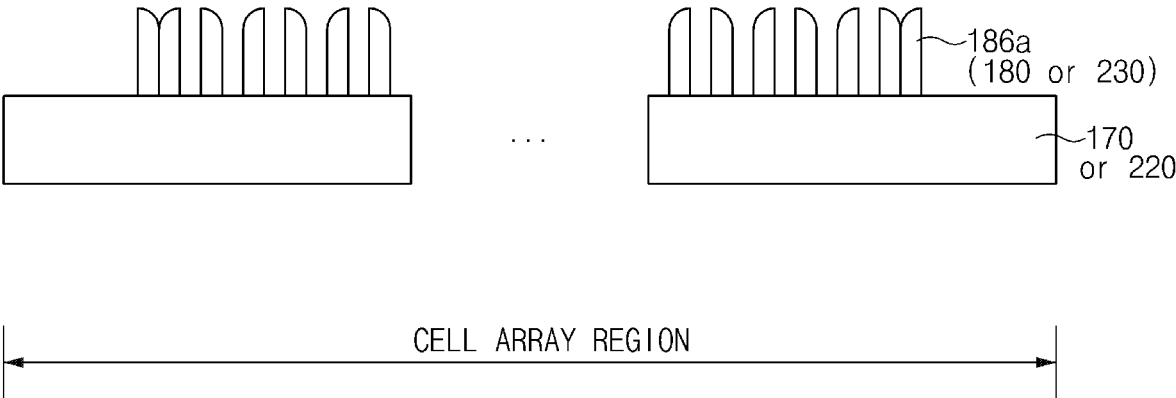


FIG. 2C

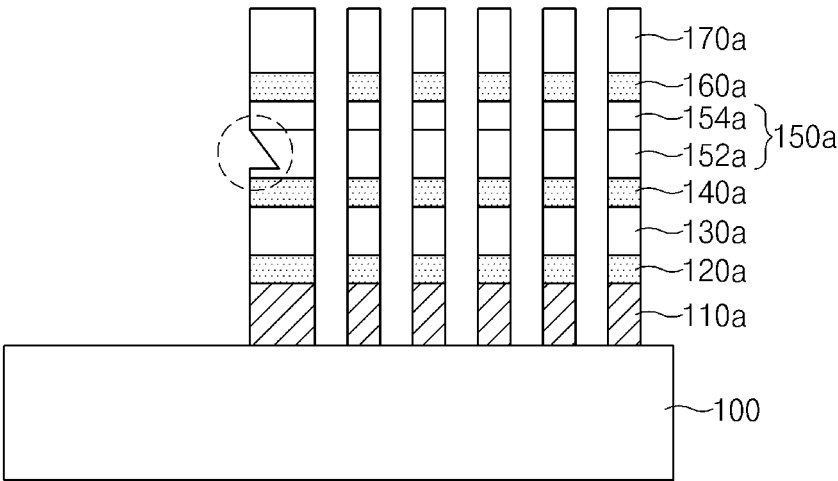


FIG. 3

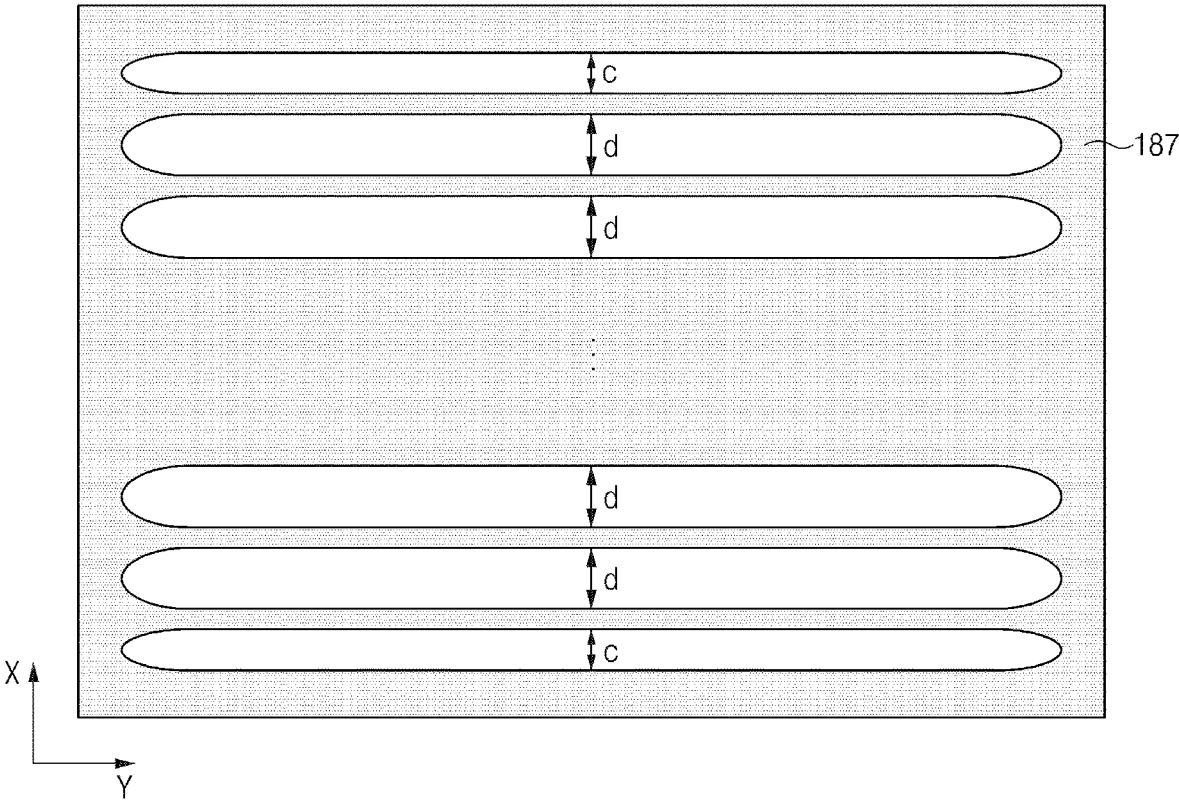


FIG. 4

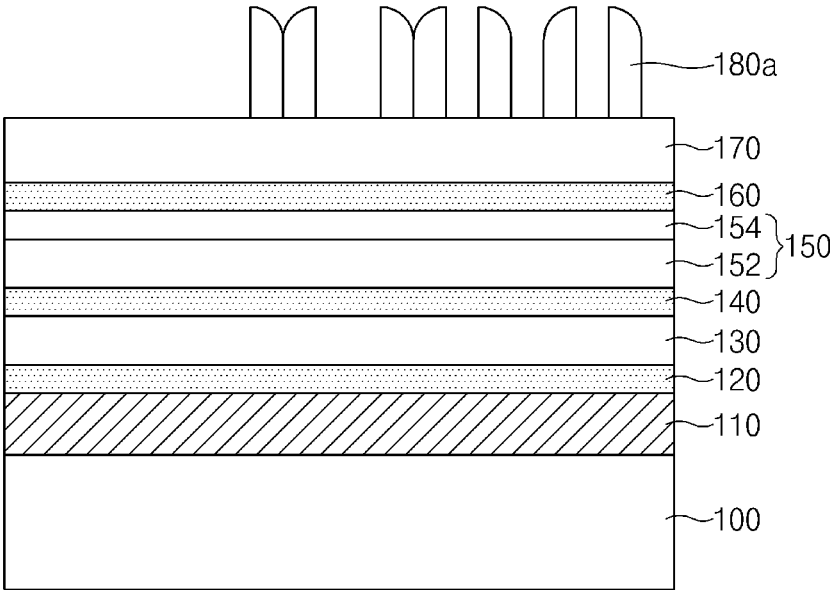


FIG. 5

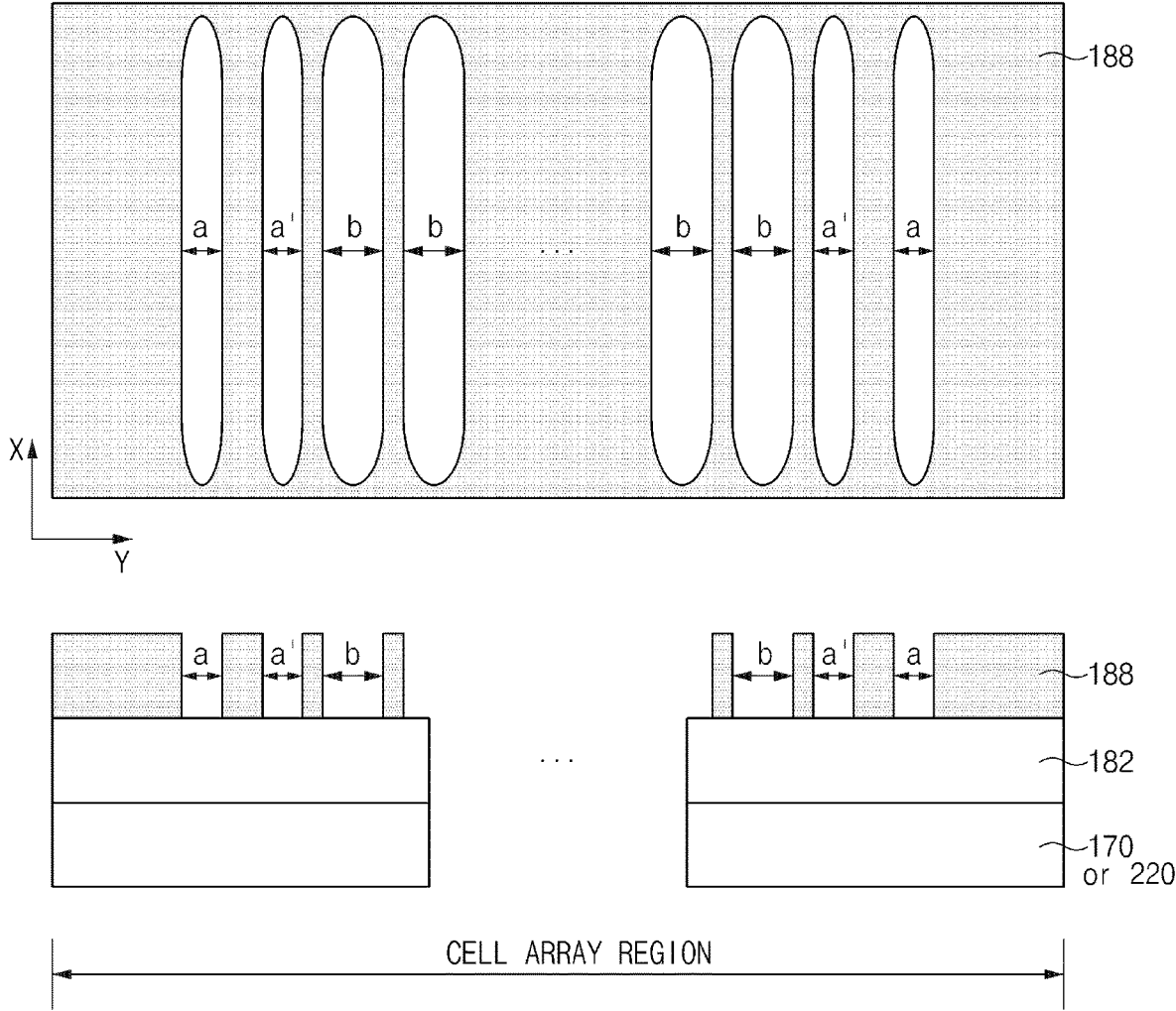


FIG. 6

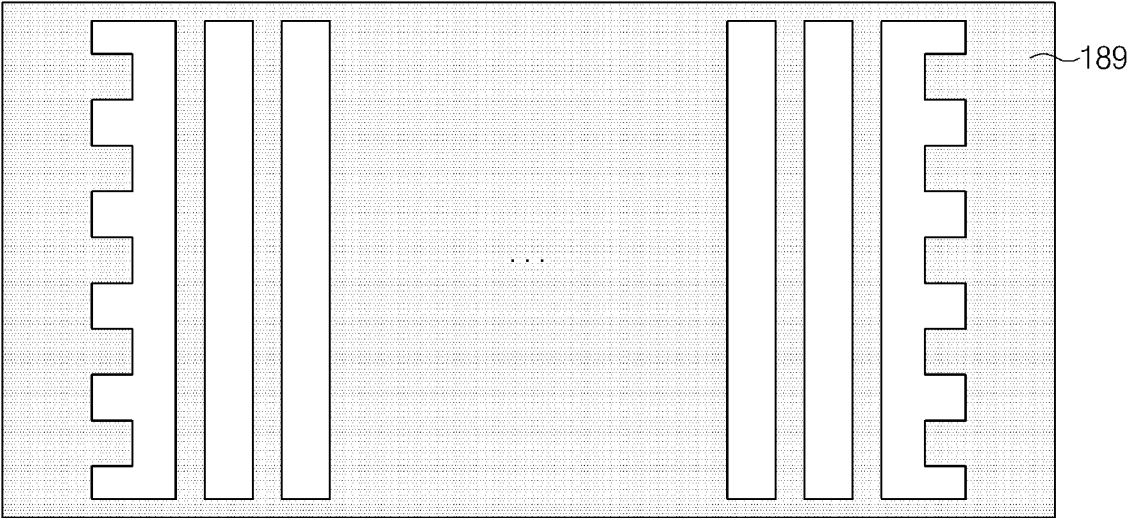


FIG. 7

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METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This patent document claims the priority and benefits of Korean patent application No. 10-2018-0132751 filed on Nov. 1, 2018, which is hereby incorporated in its entirety by reference.

The technology and implementations disclosed in this patent document relate to a method for forming a semiconductor device, and more particularly to a method for forming a cell array of a phase change semiconductor device to prevent leaning of a phase change structure formed at an outermost patterning part during patterning of the cell array of the phase change semiconductor device.

BACKGROUND

With rapid development of mobile and digital information communication technology and the household appliances industry, it is expected that research into conventional devices based on charge control of electrons will rapidly reach physical limitations. Therefore, new-generation functional memory devices instead of the conventional electron-charge devices are being developed. Especially, in order to satisfy demand for higher storage capacity of each memory for use in principal information devices, next-generation higher-capacity, higher-speed, and lower-power-consumption memory devices are being developed.

In recent times, variable resistance memory devices in which resistor elements are used as memory media have been proposed as next-generation memory devices. Representative examples of the variable resistance memory devices include a phase change memory device, a resistive memory device, and a Spin Transfer Torque Magnetic Random Access Memory (STT-MRAM).

A resistive memory device includes switching elements and resistor elements, and stores data "0" or "1" according to state information of the resistor elements.

SUMMARY

This disclosure provides a method for forming a semiconductor device that substantially obviates one or more problems due to limitations and disadvantages of the related art.

An embodiment of the present disclosure relates to a method for forming a semiconductor device to prevent leaning of a phase change structure formed at an outermost patterning part during patterning of a cell array of a phase change semiconductor device.

In accordance with an aspect of the present disclosure, a method for forming a semiconductor device includes forming a first sacrificial film over a target layer, forming a first partition mask over the first sacrificial film, forming a first sacrificial film pattern by etching the first sacrificial film using the first partition mask, forming a first spacer over a sidewall of the first sacrificial film pattern, and forming a first spacer pattern by removing the first sacrificial film pattern. The first partition mask includes a plurality of first line-shaped spaces extending in a first direction. The width of first edge spaces disposed at edges of the first line-shaped spaces is less than a width of the first line-shaped spaces disposed between the first edge spaces.

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In accordance with another aspect of the present disclosure, a method for forming a semiconductor device includes forming a sacrificial film over a target layer, forming a partition mask over the sacrificial film, forming a sacrificial film pattern by etching the sacrificial film using the partition mask, forming a spacer over the sacrificial film pattern, and forming a spacer pattern by removing the sacrificial film pattern. The partition mask includes a plurality of spaces. Sides of outermost spaces from among the plurality of spaces have a shape with a plurality of alternating protrusions and recesses.

It is to be understood that both the foregoing general description and the following detailed description of embodiments are exemplary and explanatory.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages of the present disclosure will become readily apparent by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIGS. 1A to 1G are cross-sectional views illustrating a method for forming a cell array of a phase change memory device according to an embodiment of the disclosed technology.

FIGS. 2A to 2C are views illustrating a method for forming a mask pattern according to an embodiment of the disclosed technology.

FIG. 3 is an exemplary view illustrating that a phase change material layer of an outermost pattern is damaged by an etchant.

FIG. 4 is a structural view illustrating a partition mask for forming a mask pattern extending in a Y-axis direction according to an embodiment of the disclosed technology.

FIG. 5 is a structural view illustrating a mask pattern according to another embodiment of the disclosed technology.

FIG. 6 is a structural view illustrating a partition mask according to another embodiment of the disclosed technology.

FIG. 7 is a structural view illustrating a partition mask according to yet another embodiment of the disclosed technology.

DESCRIPTION OF EMBODIMENTS

Reference will now be made in detail to certain embodiments, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or similar parts. In the following description, a detailed description of related known configurations or functions incorporated herein will be omitted to avoid obscuring the subject matter.

FIGS. 1A to 1G are cross-sectional views illustrating a method for forming a cell array of a phase change memory device according to an embodiment of the disclosed technology.

Referring to FIG. 1A, a conductive material layer **110** and a selection device layer **130** may be formed over a semiconductor substrate **100** including a plurality of lower structures (not shown).

The conductive material layer **110** may include a metal material such as tungsten (W). The conductive material layer **110** may be patterned in a subsequent process, and may thus be used as a word line WL of a phase change memory device.

One electrode layer **140** may be formed over the selection device layer **130**, and the other electrode layer **120** may be formed below the selection device layer **130**. In other words, as shown in FIG. 1A, the first electrode layer **120**, the selection device layer **130**, and the second electrode layer **140** may be sequentially stacked over the conductive material layer **110**. Each of the electrode layers **120** and **140** may include one or more of aluminum (Al), copper (Cu), tungsten (W), titanium (Ti), tantalum (Ta), titanium tungsten (TiW), titanium aluminum (TiAl), carbon (C), titanium nitride (TiN), titanium aluminum nitride (TiAlN), tantalum nitride (TaN), tungsten nitride (WN), molybdenum nitride (MoN), niobium nitride (NbN), titanium silicon nitride (TiSiN), titanium boron nitride (TiBN), zirconium silicon nitride (ZrSiN), tungsten silicon nitride (WSiN), tungsten boron nitride (WBN), zirconium aluminum nitride (ZrAlN), molybdenum aluminum nitride (MoAlN), tantalum silicon nitride (TaSiN), tantalum aluminum nitride (TaAlN), titanium oxynitride (TiON), titanium aluminum oxynitride (TiAlON), tungsten oxynitride (WON), tantalum oxynitride (TaON), titanium carbonitride (TiCN), and tantalum carbonitride (TaCN).

The selection device layer **130** may include an ovonic threshold switching (OTS) material layer formed of a specific material which is switched to an on or off state according to a voltage or current applied to the selection device layer **130**. When the magnitude of voltage or current applied to the selection device layer **130** is equal to or lower than a predetermined threshold value, the OTS material layer may prevent flowing of such current. When the magnitude of voltage or current applied to the selection device layer **130** is higher than a predetermined threshold value, the OTS material layer may allow such current to flow in proportion to the applied voltage or current. The OTS material layer may be formed of a combination of chalcogenide materials that include tellurium (Te), selenium (Se), germanium (Ge), silicon (Si), arsenic (As), titanium (Ti), sulfur (S), and antimony (Sb). Alternatively, the selection device layer **130** may include a plurality of device layers, each of which is formed of a stacked structure of an N-type oxide semiconductor layer and a P-type oxide semiconductor layer and thus has switching characteristics. For example, the selection device layer **130** may include an NPN or PNP selection device or a P-N diode.

Referring to FIG. 1B, a variable resistance layer **150**, an electrode layer **160**, and a hard mask layer **170** may be sequentially formed over the electrode layer **140**. In this case, the variable resistance layer **150** may include a stacked structure of a variable layer **152** and a metal storage electrode layer **154**.

The variable layer **152** may include a variable resistance material layer having variable resistance characteristics. For example, the variable layer **152** may include a phase change material layer. The phase change material layer may be formed of a specific material capable of storing data according to a crystalline state. For example, the phase change material may be formed of a phase change chalcogenide alloy such as germanium antimony tellurium (GST) (e.g., Ge—Sb—Te material such as $\text{Ge}_2\text{Sb}_2\text{Te}_5$, $\text{Ge}_2\text{Sb}_2\text{Te}_7$, GeSb_2Te_4 , or GeSb_4Te_7). In addition, the variable layer **152** may include a binary oxide material provided with a transition metal oxide (TMO), a perovskite-based metal oxide material, a magnetic layer used as a constituent material of a magnetic memory, or a magnetization reversal material layer used as a constituent material of STT-MRAM. For example, the binary oxide material including transition metal oxide (TMO) may include titanium oxide (TiO_2),

hafnium oxide (HfO_2), zirconium oxide (ZrO_2), aluminum oxide (Al_2O_3), tantalum oxide (Ta_2O_5), niobium oxide (Nb_2O_5), lanthanum oxide (La_2O_3), nickel oxide (NiO), copper oxide (CuO), cobalt oxide (Co_3O_4), tungsten oxide (WO_3), etc. Examples of the perovskite-based metal oxide material may include SrTiO_3 (STO), BaTiO_3 (BTO), $\text{Pr}_{1-x}\text{Ca}_x\text{MnO}_3$ (PCMO), etc. The electrode layer **160** may be formed of, for example, the same materials as the first electrode layer **120** and the second electrode layer **140**.

Although the variable resistance layer **150** according to the embodiment shown in FIG. 1B is formed over the selection device layer **130**, the scope of the present disclosure is not limited thereto, and the variable resistance layer **150** may also be formed below the selection device layer **130**.

Referring to FIG. 1C, line-shaped mask patterns **180** extending in a first direction (e.g., an X-axis direction) may be formed over a hard mask layer **170** using Spacer Patterning Technology (SPT). In this case, the mask patterns **180** may be formed so that the outermost pattern has a greater width than each of inner patterns.

FIGS. 2A to 2C are views illustrating a method for forming the mask pattern **180** according to an embodiment of the disclosed technology.

Referring to FIG. 2A, a sacrificial film **182** may be formed over a hard mask layer **170**, and a partition mask **184** may be formed over the sacrificial film **182**.

In this case, the sacrificial film **182** may be formed of Spin On Carbon (SOC), and the partition mask **184** may be a photoresist pattern formed by a photolithography process.

Specifically, widths (a) and (b) of line-shaped spaces extending in a first direction from the partition mask **184** may be non-uniformly formed in a cell array region. The width (a) of each outermost space formed at opposing outermost edges of the partition mask **184** may be smaller than the other width (b) of each space formed between the outermost spaces, as represented by "a<b". In this case, the spaces may be spaced apart from each other by the same distance. In other words, the distance between every two adjacent spaces in a space pattern may be the same.

For example, the width (a) of both outermost spaces of the partition mask **184** may be smaller than the width (b) of each of the remaining spaces formed between both outermost spaces. In this case, in a subsequent spacer formation process, the width (a) of the outermost space may have a specific length (for example, a length corresponding to about twice the spacer width) that allows side surfaces of spacers formed in the corresponding space to be brought into contact with each other. Here, the term "about" refers to normal engineering tolerances to accommodate minor variations from the target width, e.g. the width of two spacers. That is, the width (a) of the outermost space may be appropriately sized to facilitate proper formation of spacers formed in a subsequent process. Alternatively, the width (a) of the outermost space may be greater than the width of a spacer so that respective spacers are located very close to each other without being laterally in contact with each other such that the corresponding spacers can function as a single pattern.

The reason why each outermost space is formed to have the width (a) as described above is to increase a width of pattern formed at edges of a cell array. The increased width of pattern at edges of the cell array helps to protect cell structures from being damaged in an etching process.

Referring to FIG. 2B, the sacrificial film **182** may be etched by an etching process in which the partition mask **184** is used as an etch mask, thereby sacrificial film pattern **182a**, which may be referred to as a partition pattern.

Subsequently, a spacer insulation film **186** may be formed over the sacrificial film pattern **182a** and the hard mask layer **170**. The spacer insulation film **186** may be deposited over sidewalls of the sacrificial film pattern **182a**. The spacer insulation film **186** may be formed by conformally depositing a material having an etch rate selectivity that is different from that of the sacrificial film pattern **182a**. For example, when the sacrificial film pattern **182** is formed of Spin On Carbon (SOC) having carbon (C), the spacer insulation film **186** may be formed of an Ultra Low Temperature Oxide (ULTO).

Referring to FIG. 2C, the spacer insulation film **186** may be anisotropically etched until a top surface of the sacrificial film pattern **182** is exposed outside, the exposed sacrificial film pattern **182a** is removed such that a spacer pattern **186a** may be formed over the hard mask layer **170**. The sacrificial film pattern **182a** may be removed by an etch-back process using an etch selection ratio between the sacrificial film pattern **182a** and the spacer pattern **186a**.

The spacer pattern **186a** may be identical to the mask pattern **180** of FIG. 1C. In other words, the mask pattern **180** that comprises a plurality of spacers may be alternately referred to as a mask pattern **180** because it functions as a mask, or a spacer pattern **186a** because it is a pattern of spacers.

Referring back to FIG. 1D, the hard mask layer **170** may be etched using the mask pattern **180**, which is formed by the fabrication methods shown in FIGS. 2A to 2C, as an etch mask, thereby forming a hard mask pattern **170a**. Subsequently, the electrode layer **160**, the variable resistance layer **150**, the electrode layer **140**, the selection device layer **130**, the electrode layer **120**, and the conductive material layer **110** may be sequentially etched using the hard mask pattern **170a** as an etch mask, such that an electrode layer **160a**, a variable resistor **150a**, an electrode layer **140a**, a selection device **130a**, an electrode **120a**, and a conductive line **110a** may be formed.

That is, the patterned electrode **160a**, the variable resistor **150a**, the electrode **140a**, the selection device **130a**, the electrode **120a**, and the conductive line **110a** may be formed in a line pattern extending in a first direction. Although the hard mask pattern **170a** is illustrated in FIG. 1D for convenience of description, the scope of the present disclosure is not limited thereto, and the hard mask pattern **170a** may be removed in a patterning process. The conductive line **110a** may function as a word line (WL) of the phase change memory device.

For convenience of description and better understanding of the present disclosure, the line-shaped electrode **160a** and the line-shaped variable resistor **150a** may be integrated into a single group and this group will hereinafter be referred to as a phase change line. In addition, the line-shaped electrode **140a**, the line-shaped selection device **130a**, and the line-shaped electrode **120a** may be integrated into a single group and this group will hereinafter be referred to as a switching line.

However, in the above patterning process, there is a high possibility that the outermost pattern formed at the outermost edge is more damaged by an etchant than inner patterns. That is, the inner patterns are spaced apart from each other by a very short distance such that there is a low probability that the inner patterns are damaged by the etchant. In contrast, the outer space located outside the outermost pattern may be relatively large, such that there is a high probability that a variable resistance material layer (especially, a phase change material layer such as GST) of

the outermost pattern is damaged by the etchant as shown in the dashed line circle of FIG. 3.

Therefore, when the outermost pattern is formed to have the same width as each of the inner patterns, a fault or defect may occur in the semiconductor device due to leaning of the outermost pattern.

In order to prevent leaning of the outermost pattern, an embodiment may form a protective pattern at the outermost edge, and may allow the outermost pattern (i.e., protective pattern) to be wider than each of the inner patterns. As a result, even when the outermost pattern is damaged, the outermost pattern is prevented from leaning.

Although only the outermost pattern formed on one side of a cell array is shown in FIGS. 1C and 1D for convenience of description and better understanding of the present disclosure, the scope of the present disclosure is not limited thereto. Each of the outermost patterns located at opposite sides of the cell array may be wider than central structures in the cell array as illustrated in FIGS. 2A to 2C.

Referring to FIG. 1E, the outermost patterns formed at both sides of the cell array may be removed using a cast mask. Subsequently, an insulation film **210** may be formed over a semiconductor substrate **100**, a conductive line **110a**, a plurality of switching lines **120a**, **130a**, and **140a**, a plurality of phase change lines **150a** and **160a**, and a hard mask pattern **170a**. The insulation film **210** may be planarized by a planarization process (e.g., a Chemical Mechanical Polishing (CMP) process) until upper surfaces of the electrode **160a** are exposed.

The insulation film **210** may have a monolayer or multilayer structure that is formed of various insulation materials, for example, an oxide material, a nitride material, or a combination thereof.

Subsequently, a metal film **220** may be formed over the planarized insulation film **210** and the electrode **160a**. The metal film **220** may be electrically coupled to the electrode **160a**.

Referring to FIG. 1F, a line-shaped mask pattern **230** extending in a second direction (e.g., a Y-axis direction) perpendicular to the first direction may be formed over the metal film **220**.

The mask pattern **230** may be formed using Spacer Patterning Technology (SPT), as shown in FIGS. 2B and 2C, using a partition mask **187** in which line-shaped spaces extending in the second direction are formed as shown in FIG. 4. In this case, the width (a) and (b) of the spaces formed in the partition mask **187** may be non-uniformly formed in the cell array region. The width (c) of each of the outermost space patterns formed at the outermost edges of the partition mask **187** may be smaller than the width (d) of each of the space patterns formed between the outermost space patterns, as represented by " $c < d$ ". In an embodiment, the spaces may be spaced apart from each other by the same distance.

That is, the outermost patterns of the mask pattern **230** may be formed to interconnect two spacers, such that each outermost pattern is formed to have a larger width than each inner pattern formed of only one spacer. An example of two interconnected spacers can be seen in FIG. 2C, where the outermost two spacers on both sides of the spacer pattern **186a** are touching.

Due to the similarities between forming mask pattern **180** and mask pattern **230**, a detailed description of the method for forming the mask pattern **230** will herein be omitted for convenience of description.

Referring to FIG. 1G, the metal film **220** may be etched using the mask pattern **230** as an etch mask, resulting in

formation of a conductive line **220a**. Phase change lines **160a** and **150a** formed below the conductive line **220a** and the switching lines **140a**, **130a**, and **120a** may be sequentially etched, such that cell-isolated phase change patterns and switching patterns corresponding to the respective phase change patterns may be formed.

That is, a plurality of phase change layers and switching layers may be formed between word lines **110a** and bit lines **220a** that are oriented perpendicular to the word lines **110a**.

Protective patterns at the outermost edge having a larger width than central lines may be removed by a cut mask.

FIG. **5** is a structural view illustrating a mask pattern according to another embodiment of the disclosed technology.

Referring to FIG. **5**, for implementation of more stable patterning, a mask pattern **180a** may be configured so that two masking elements at each of the outermost edges of the pattern are larger than masking elements in the middle of the pattern. For example, as seen in FIG. **5**, the two sets of spacers on the left edge of the pattern each comprise two connected spacers so that those elements are twice as wide as the elements in the middle of the spacer pattern, which each have a single spacer.

In the partition mask **188** for SPT fabrication shown in FIG. **6**, each of the width (a) of an outermost space and the width (a') of a space located adjacent to the outermost space is smaller than the width (b) of each of other inner spaces located closer to the center of the partition mask **188**, resulting in formation of the mask pattern **180a** in FIG. **5**. In various embodiments, the width (a) of the outermost space and the width (a') of the contiguous space located adjacent to the outermost space may be the same or different from each other.

The mask pattern **180a** of FIG. **5** may be formed by performing SPT fabrication as shown in FIGS. **2B** and **2C** using the partition mask **188** of FIG. **6**. Therefore, a detailed description of the method for forming the mask pattern **180a** will be omitted for convenience of description.

FIG. **7** is a structural view illustrating a partition mask according to yet another embodiment of the disclosed technology.

Referring to FIG. **7**, a spacer patterning technology (SPT) partition mask **189** may have an alternating series of protrusions and recesses. For example, the outer sidewalls of the outermost spaces in the space pattern shown in partition mask **189** of FIG. **7** have an alternating series of protrusions and recesses.

As illustrated in FIG. **7**, since the outer sidewall of the outermost space of the partition mask **189** has a series of protrusions and recesses, spacers located in a series of protrusions and recesses may be formed to contact each other, or may be located very close to each other. As seen in the figure, the alternating protrusions and recesses are oriented away from the plurality of spaces.

As a result, each of the outermost patterns of the mask pattern may be formed to have a larger width than each of other inner patterns.

As is apparent from the above description, methods for forming semiconductor devices according to embodiments of the present disclosure may prevent leaning of a phase change structure formed at an outermost patterning part during patterning of a cell array of a phase change semiconductor device.

Those skilled in the art will appreciate that the embodiments may be carried out in other specific ways than those set forth herein without departing from the spirit and essential characteristics of the disclosure. The above embodi-

ments are therefore to be construed in all aspects as illustrative and not restrictive. The scope of the disclosure should be determined by the appended claims and their legal equivalents, not by the above description. Further, all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein. In addition, it is obvious to those skilled in the art that claims that are not explicitly cited in each other in the appended claims may be presented in combination as an embodiment or included as a new claim by a subsequent amendment after the application is filed.

Although a number of illustrative embodiments have been described, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. Particularly, numerous variations and modifications are possible in the component parts and/or arrangements which are within the scope of the disclosure, the drawings and the accompanying claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. A method for forming a semiconductor device comprising:
 - forming a first sacrificial film over a target layer;
 - forming a first partition mask over the first sacrificial film;
 - forming a first sacrificial film pattern by etching the first sacrificial film using the first partition mask;
 - forming a first spacer over a sidewall of the first sacrificial film pattern; and
 - forming a first spacer pattern by removing the first sacrificial film pattern,
 wherein the first partition mask includes a plurality of first line-shaped spaces extending in a first direction, and wherein a width of first edge spaces disposed at edges of the first line-shaped spaces is less than a width of the first line-shaped spaces disposed between the first edge spaces.
2. The method according to claim 1, wherein the first edge spaces include both outermost spaces from among the plurality of first line-shaped spaces.
3. The method according to claim 2, wherein the first edge spaces further include:
 - spaces located adjacent to each of the outermost spaces.
4. The method according to claim 1, wherein forming the first spacer includes depositing a first spacer film so it completely covers regions corresponding to the first edge spaces in the first sacrificial film pattern.
5. The method according to claim 4, wherein the width of the first edge spaces is about twice a width of the first spacer.
6. The method according to claim 1, wherein the target layer includes:
 - a selection device layer; and
 - a variable resistance layer formed over or below the selection device layer.
7. The method according to claim 6, wherein the selection device layer includes an ovonic threshold switch (OTS) material layer.
8. The method according to claim 7, wherein the selection device layer further includes:
 - an electrode layer formed over or below the selection device layer.
9. The method according to claim 6, wherein the variable resistance layer includes a phase change material layer.

10. The method according to claim 9, wherein the phase change material layer includes a germanium antimony tellurium (GST) material.

11. The method according to claim 1, further comprising:
forming a line-shaped target layer pattern comprising 5
line-shaped structures extending in the first direction by
etching the target layer using the first spacer pattern;
forming a metal film over the target layer pattern;
forming a second sacrificial film over the metal film;
forming a second partition mask over the second sacrifi- 10
cial film;
forming a second sacrificial film pattern by etching the
second sacrificial film using the second partition mask;
forming a second spacer over a sidewall of the second
sacrificial film pattern; and 15
forming a second spacer pattern by removing the second
sacrificial film pattern,
wherein the second partition mask includes a plurality of
second line-shaped spaces extending in a second direc- 20
tion perpendicular to the first direction, and
wherein a width of second edge spaces disposed at edges
of the second line-shaped spaces is less than a width of
second line-shaped spaces disposed between the sec-
ond edge spaces.

12. The method according to claim 11, further compris- 25
ing:
forming a conductive line by etching the metal film in the
second direction using the second spacer pattern; and
forming a memory cell by etching a portion of the target
layer pattern exposed by the conductive line in the 30
second direction.

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